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COST CONSIDERATIONS OF AN INTEGRATED DESIGN-MANUFACTURING-SUPPORT SYSTEM

Richard T. Cheslow, *Project Leader*
James D. McCullough

June 1989

Prepared for
Assistant Secretary of Defense, Production and Logistics

INSTITUTE FOR DEFENSE ANALYSES
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This document is an annotated briefing that focuses on the cost considerations of integrated technical information systems. Primary emphasis is placed on Computer-Aided Acquisition and Logistics Support (CALS) systems. After a review of selected DoD prime contractors' practices, a cost/benefit structure that is appropriate for use with advanced technology information systems is presented and discussed. A summary of the costs and benefits of computer-aided systems is presented, together with examples of management information systems appropriate to the cost/benefit structure.

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June 1989

INSTITUTE FOR DEFENSE ANALYSES

Contract MDA 903 84 C 0031
Task T-B7-591

PREFACE

This briefing book was prepared by the Institute for Defense Analyses (IDA) for the Office of the Assistant Secretary of Defense, Production and Logistics (OASD/P&L) under contract MDA 903 84 C 0031, Task Order T-B7-591, issued 13 April 1988.

The purpose of the task is to provide OASD/P&L with a better understanding of industry cost structures associated with integrated design-manufacturing-support (IDMS) systems and to explore potential cost savings associated with the implementation of IDMS systems.

This work has been reviewed by Dr. Thomas P. Frazier and Dr. James P. Pennell of IDA.

TABLE OF CONTENTS

INTRODUCTION

The idea of using digitized data output from a variety of analytic systems as input for a large number of logistics and acquisition activities has evolved over many years. An increasing number of computer-aided applications in industry and a few independent applications within the Department of Defense (DoD) resulted in a growing belief that more extensive use of digital data could improve the efficiency and lower the costs (in the long run) of the DoD's acquisition and logistics functions. A memorandum was issued in April 1984 [1] recognizing "an opportunity for major advances in generation, integration, and use of logistic technical information" and chartering a joint DoD-industry group to study the concept and make recommendations. That group recommended [2] "that a DoD policy be established that will both direct and encourage the integration of existing 'islands of automation' and facilitate the transition of logistics processes within DoD and industry from paper-based to digital mode in an orderly way."

Shortly after the issuance of the group's report, the Deputy Secretary of Defense issued a policy memorandum [3] initiating the Computer-Aided Logistics Support (CALS) program with the goal of acquiring technical data in digital form from contractor databases by 1990. A CALS Program Office was established in OSD by a memorandum from the Under Secretary of Defense for Acquisition on October 30, 1986. Because of industry's heavy involvement and the inclusion of acquisition functions, the name of the program became the Computer-Aided Acquisition and Logistics Support System. Annual reports have been submitted to Congress on the progress and plans for CALS implementation [4 through 6]. In August 1988, the Deputy Secretary of Defense issued another memorandum on CALS [7], directing the Services and the Defense Logistics Agency (DLA) to apply the CALS concept to all systems entering development after September 1988 to review opportunities of applying CALS to systems currently in full-scale development or production, and to program for building a CALS infrastructure within DoD to receive and use digitized data.

In order to succeed, CALS must be a joint government-industry effort [8]. The government must be ready to require, receive, and use digitized data efficiently and the private sector must be able to respond competitively to supply data in that form. It was recognized that a better understanding of the cost implications of applying integrated design-manufacturing-support

BRIEFING CONTENT

- BACKGROUND
- TASK 1: DATA COLLECTION
- TASK 2: COST/BENEFIT STRUCTURE FOR IDMS SYSTEMS
  - METHODOLOGY
  - STRUCTURES
- TASK 3: INFORMATION SYSTEM SAVINGS
- TASK 4: RECOMMENDATIONS

systems was needed. That understanding could then be applied in the development of the government infrastructure and in the encouragement of system installations within the private sector. By encouraging the private sector to invest in integrated systems, the DoD could help ensure a high level of economic and effective competition in the weapon system acquisition process. IDA was requested to assist by exploring potential cost savings associated with computer-aided systems and by reviewing industry cost structures used in evaluating those systems [9].

This briefing presents our findings during an initial review of the costs and benefits of integrated systems and of the cost structures being used to evaluate them.

Slide 1

The briefing is presented in five parts. After a short introduction, we will note the data collection performed in accordance with the task order and discuss cost/benefit methodology as it applies to the justification and tracking of the costs and benefits of implementation of CALS-type advanced technology systems. A "strawman" cost structure will be shown to provide a starting point for future effort. This will be followed by a presentation of typical costs and benefits which have been claimed or estimated in the literature and in the briefings we received during our visits to selected contractors. The briefing ends with a number of recommendations.

BACKGROUND

- WHAT IS CALS?
- PROBLEM ADDRESSED
- SCOPE

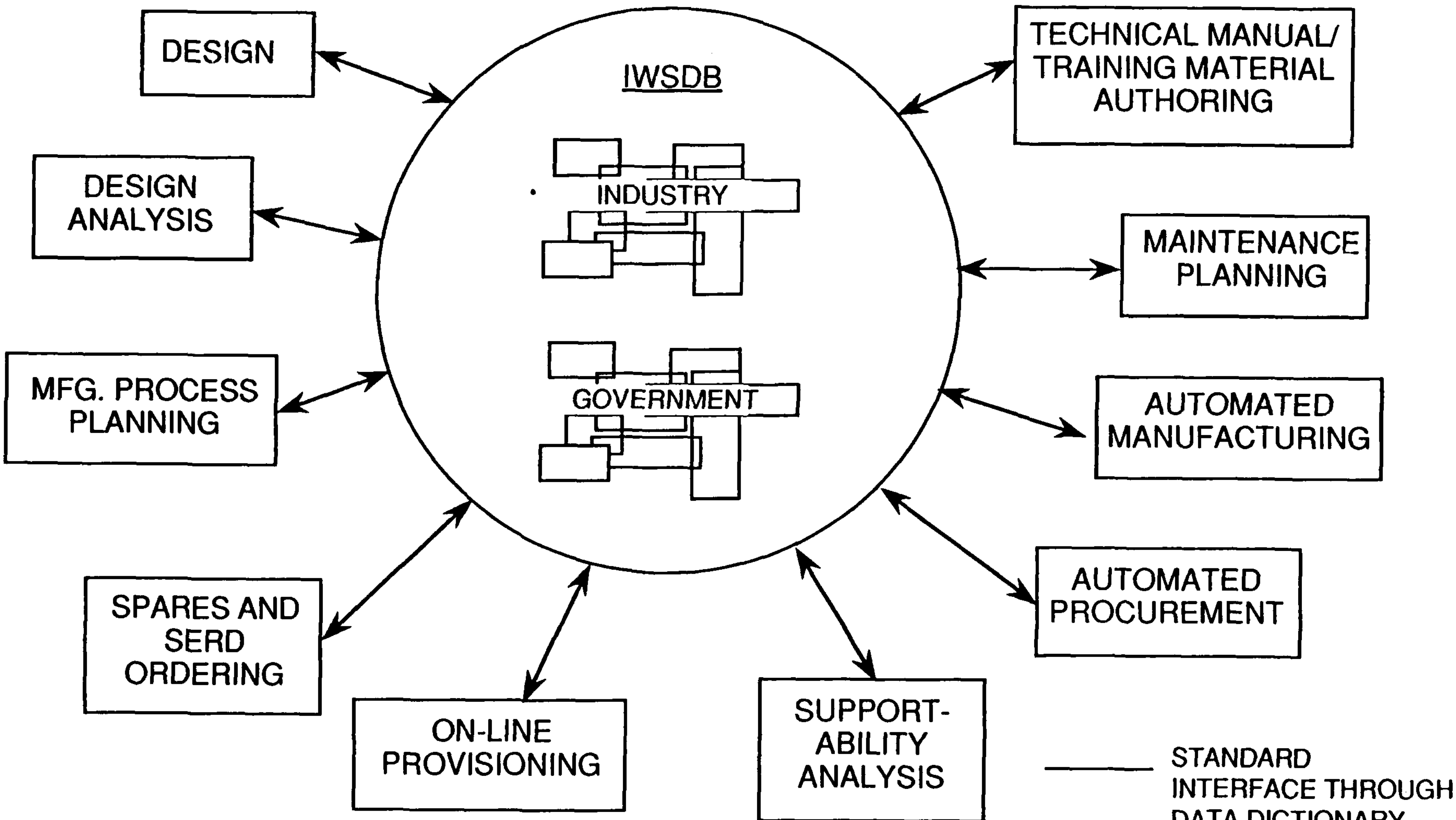
BACKGROUND

Slide 2

We found that some confusion exists in the definition of CALS within the context of integrated design-manufacturing-support (IDMS) systems. After defining CALS, we will note the problem(s) addressed in the task order and outline the scope of the work summarized in this briefing.

BACKGROUND

PHASE II INTEGRATION TARGET INTEGRATED WEAPON SYSTEM DATABASE (IWSDB)



Slide 3

The first CALS report [2] presented two primary recommendations. One was to integrate the many computer-aided tools and methodologies to promote the automation of the design process. The second was to move from a paper-based information system to one that centered on the use of digital electronic media.

This second primary recommendation, in turn, evolved into a two-phase plan. Phase I called for the development of interface standards to allow contractors to deliver required data to the government electronically. Phase II calls for the development of a common database concept. With this database concept, the implied mode of data use by the government is to "pull" information. The government would be able to query the database and "pull" the information needed for analysis, evaluation, and simulation using electronic rather than paper media. The need for hard-copy data deliverables and the handling, storage, and transportation resources that accompany this form of delivery shrinks dramatically.

Communication standards are relatively well-defined. Protocols exist for remote accessing, for sending and receiving information and for transferring files. The primary problem now is to be able to precisely define objects and attributes.

WHAT IS CALS?

COMPUTER-AIDED ACQUISITION AND LOGISTIC SUPPORT

CALS IS AN ENABLING CONCEPT

- CALS IS NOT:
  - -- A HARDWARE UNIT
  - -- A SET OF SOFTWARE
  - -- A FORMALIZED PROCEDURE
- CALS IS:

". . . A DoD AND INDUSTRY INITIATIVE TO ENABLE AND ACCELERATE THE USE AND INTEGRATION OF . . . DIGITAL TECHNICAL INFORMATION FOR WEAPON SYSTEM ACQUISITION, DESIGN, MANUFACTURE AND SUPPORT."

- 1988 CALS REPORT TO CONGRESS

THE COMMUNICATION AND INTERCHANGE OF DATA AMONG COMPUTERIZED FUNCTIONAL SYSTEMS THROUGH CENTRALIZED AND INTEGRATED DATABASES.

Slide 4

CALS is not a specific hardware/software system. It is the phrase used to describe the initiative and encouragement of the communication and use of digital data, stored in centralized databases, throughout the life cycle of a system. As data and information are needed to perform an activity, it may be electronically accessed rather than using paper for information transfer. When information is updated in the databases, it would be immediately available to users rather than requiring time-consuming paper reproduction and distribution.

PROBLEM

"WHILE IT IS BELIEVED THAT INTRODUCTION OF SUCH SYSTEMS [INTEGRATED DATABASES AND INFORMATION SYSTEMS] IS RESULTING IN EFFICIENCIES, IT IS NOT YET APPARENT EXACTLY WHERE THE COST SAVINGS ARE OCCURRING . . ."

- IDA TASK ORDER T-B7-591

Slide 5

The guiding phrase in this statement of the problem is that the location of the expected benefits from CALS implementation "is not yet apparent". One of the goals of this phase of the task is to determine where the savings will probably appear.

SCOPE

- THREE- TO FIVE-YEAR EFFORT TO "INVESTIGATE THE NATURE OF EFFICIENCIES AND COST SAVINGS ASSOCIATED WITH THE INTRODUCTION OF CALS" AND TO "EXPLORE OPPORTUNITIES FOR FURTHER SAVINGS"

  - IDA TASK ORDER T-B7-591

- WORK TO BE DONE IN PHASES

- PHASE I EFFORT (TASKS):

  1. OBTAIN AND DOCUMENT COST/BENEFIT INFORMATION AND EXAMPLES FROM SELECTED AEROSPACE PRIME AND SUBCONTRACTORS

  2. DEVELOP A STRUCTURE FOR ANALYZING COSTS AND BENEFITS FOR PEOPLE-INTENSIVE FUNCTIONS FOR MAJOR AIRCRAFT SYSTEMS

  3. INVESTIGATE COST SAVINGS OF IDMS INFORMATION SYSTEMS, AND REVIEW AND SUMMARIZE INDUSTRY COST/BENEFIT STUDIES

  4. RECOMMEND FOLLOW-ON TASKS

Slide 6

To our knowledge, no operational, fully-integrated Phase II CALS system has been installed. Therefore, the investigation of the costs and benefits of a fully-integrated system will require much time. The total effort may take three to five years as parts of the system are installed and evaluated. The work has been divided into phases. We have completed Phase I, which called for:

(1) collection of the costs and benefits information that may be available at this time from DoD contractors who have started to implement CALS (The aerospace industry was chosen for this initial review.)

(2) development of an appropriate structure for analyzing the costs and benefits that would apply to the analysis of the application of advanced technology to people-intensive functions (Today's cost and benefit structures tend to parallel a system's work breakdown structure, which, in turn, parallels a system's components and parts. These structures are hardware-oriented and emphasize the direct labor and materials used in manufacturing. Little visibility is provided into those functions which develop the design, manufacturing support, and logistics support of a system. Those functions are very people-intensive and are the areas where the greatest gain is expected from IDMS applications.)

(3) overall review of existing industry cost/benefit studies and the savings on which those studies are based

(4) recommendations for work to be performed in the next phase of the task.

TASK 1: DATA COLLECTION

- **LITERATURE REVIEW**
- **MEETINGS AND CONFERENCES (9)**
  - CALS EXPO
  - CALS BNFT. STRAT. & IMPL. CONF.
  - CONCURRENT ENGR. TAG
  - AUTOFACT '88
  - CALS IAG (SUBCOMM.) (3)
  - IDS TAG (2)
- **CORPORATE VISITS AND BRIEFINGS (13)**
  - BOEING
  - NORTHROP
  - LOCKHEED CORP.
  - ITT
  - LMSC
  - TI
  - LASC
  - LASC (L-1011)
  - ROCKWELL
  - FMC
  - McDONNELL AIR
  - PRICE WATERHOUSE
  - ERNST & WHINNEY

TASK 1: DATA COLLECTION

Slide 7

Data were collected from a number of sources. In addition to a literature review, interviews were held with specific contractors and a number of meetings and conferences were attended. A summary of the literature review is shown in the Reference section. Briefing notes and memoranda on the meetings, conferences, and interviews are in our project files. We have not included the large amount of marketing literature which is readily available.

TASK 2: COST/BENEFIT STRUCTURE FOR IDMS SYSTEMS

- COST/BENEFIT METHODOLOGY
- COST/BENEFIT STRUCTURES

TASK 2: COST/BENEFIT STRUCTURE FOR IDMS SYSTEMS

Slide 8

A substantial part of the effort was spent on the review and development of cost/benefit structures. Since current structures are oriented toward system components, it was necessary to review basic cost/benefit methodology in order to develop a structure that would be applicable to IDMS systems.

Therefore, this portion of the briefing is divided into two sections. First, we will review cost/benefit methodology as it applies to IDMS. Then, we will discuss the structures currently being developed in industry and present a "strawman" structure that could serve as a starting point in future work.

NEED

NEED: PROPER ANALYTICAL FRAMEWORK FOR COST/BENEFIT STRUCTURES

PROBLEM: INDUSTRY CAPITAL BUDGET JUSTIFICATION METHODS

METHODOLOGY SOURCES: DoD COST/BENEFIT METHODOLOGY
CAM-I CONCEPTUAL DESIGN COMPONENTS

RECOMMENDATION: IDMSS COST/BENEFIT METHODOLOGY

Slide 9

Cost and benefit structures aid decision-makers by identifying where resources are used and benefits gained and by aiding in cost and benefit estimation. The structures are an integral part of the decision-making process for investing in IDMS systems. If good decisions on IDMS systems are to be made, then, not only must the structures be appropriate, but the overall process must be sound, as well.

There is evidence in the literature [10] that the present industry process for making capital equipment decisions for IDMS systems is flawed. This process, the "capital budget justification methodology", has become biased against IDMS systems, as will be discussed below.

After review of the problems with industry justification methods, we will draw upon two sources of sound methodology to recommend an IDMS *cost/benefit methodology*. *The two sources are, first, the basic cost/benefit methodology* used by the Department of Defense since its introduction by then-Comptroller Charles Hitch in 1961, and second, the specialized investment methodology developed recently by Computer Aided Manufacturing International, Inc. (CAM-I) of Arlington, Texas, for the selection of integrated manufacturing systems.

INDUSTRY JUSTIFICATION METHODS

OFTEN	SHOULD BE
FOCUS ON: ISLAND OF AUTOMATION	INTEGRATED MANUFACTURING
METHOD OF JUSTIFICATION:	
ECONOMIC	STRATEGIC
RETURN ON INVESTMENT INTERNAL RATE OF RETURN NET PRESENT VALUE PAYBACK PERIOD	INVEST FOR SURVIVAL ECONOMIC MEASURES RISK ANALYSIS INTANGIBLE BENEFITS

IDEAS FROM: REF [11]

Cost/Benefit Methodology

Slide 10

Current industry justification methods have been summarized by Meredith [11] and others. In brief, far too many firms rely on a decades-old methodologies developed when equipment decisions focused on individual machine tools. Unfortunately, the same methodology is being applied to decisions on islands of automation and flexible machine cells. The primary means of justification is that of return on investment (ROI), expressed in various formulas, and, generally, requiring a high rate of return. We will examine problems with this approach next.

Meredith and others recommend that integrated manufacturing systems, including IDMS, be justified on a "strategic" basis. That is, the focus would be on the future survival of the firm under worldwide competitive conditions. Such a methodology would still include economic measures, risk analyses, and intangible benfits.

PROBLEMS WITH TRADITIONAL APPROACHES

1. STATUS QUO ASSUMED
2. SHORT-TERM HORIZON USED
3. PROJECT BY PROJECT; NOT SYNERGISTIC COMBINATION
4. HIGH HURDLE RATES
5. NON-FINANCIAL BENEFITS OMITTED
6. LOW-LEVEL MANAGEMENT INVOLVED
7. FLEXIBILITY OF NEW EQUIPMENT OMITTED
8. COSTS ARE MISLEADING

SOURCE: Ref. [10]

Slide 11

Problems with the traditional ROI methodology have been address by Hayes [10] and others. Problems include:

(1) The **status quo** is assumed for the base case used to compare proposed alternatives. This assumption ignores what competitors, with new products and new technologies, and customers might do if the proposal is not adopted and biases financial evaluations against new investments. Using the status quo as the base case also shows a lack of attempting to understand competitors' strategies and likely reactions to one's decisions. For example, it would be unwise for an aerospace contractor to ignore his competitors' actions to prepare for CALS. Such a contractor might find himself unprepared and unable to bid on significant government contracts in the future because his "status quo" assumptions rejected CALS-type investments.

(2) A **short-term horizon** is often used for present value techniques and creates difficulties when short-term projects are compared to long-term projects **without** taking into account the replacement projects for the short-term projects. Narrow use of the present value technique can lead to an emphasis on expansion in place, rather than on building new facilities. Over time, a series of such decisions can lead to ponderous, outmoded facilities -- easy prey for smaller, modern, focused plants of competitors. Again, the need is to focus on **alternative futures** in which to evaluate each investment proposal in the light of worldwide competition.

(3) A **project-by-project** basis is often used. This procedure overlooks critical interactions with other projects and is a key reason for failure to properly justify new manufacturing technologies with their synergistic effects. That is, the full benefits will not be realized unless the total set of projects is implemented, but, when implemented, benefits far exceeding that of the sum of individual projects may be achieved.

(4) High **"hurdle rates"** may be used. The ROI level required for new projects to meet may be set far too high (40% or more), even when the actual long-term cost of capital is much lower. Higher rates are justified by:

- A need to cover the uncertainies of a new project.
- A desire to motivate managers to select the best projects (to get over the hurdle).
- A desire to raise the future average ROI by requiring a higher return on new projects.

These high rates are often completely unrealistic and discourage managers.

(5) **Non-financial benefits** are often omitted. Firms avoid quantifying qualitative factors, yet this avoidance introduces a strong bias against IDMS technologies because of their significant impact on product quality, delivery speed, reliability, and rapidity of new product introduction. New technologies have the potential of changing the way a firm's engineering, manufacturing, and logistical support organizations interact with each other and with the customer.

(6) A **low level of management** is often involved in the capital decisions. The project-by-project method often includes low-level management, to the exclusion of senior management's broader perspectives (and the broader scope of alternatives). Short-sighted decisions may be made, which look good, given the localized criteria, but are deadly to the firm in the long run.

(7) The **flexibility of the new technologies** may be omitted. Conditions are changing fast under worldwide competition, and decisions to buy specialized, inflexible equipment (as replacements for similar equipment) can lead to disaster. Decisions should consider the flexibility of new techology whenever possible so *that the firm can be responsive to changing* product lines and mixes.

(8) **Costs are often misleading** when outdated accounting systems and overhead rates are used to provide cost estimates of new alternatives. Hidden, non-value-added costs are obscured and may bias new technologies that reduce such costs. For example, an IDMS system may greatly reduce set-up time or rework time, but if these costs are hidden in existing overhead rates, then the advantage may be overlooked -- and wrong decisions made.

METHODOLOGY SOURCES

DoD COST/BENEFIT METHODOLOGY

1. FORMULATE PROBLEM
2. IDENTIFY ALTERNATIVES
3. PREDICT CONSEQUENCES

    FUTURE CONTEXT
    COSTS (COST STRUCTURES)
    BENEFITS (BENEFITS STRUCTURES)
    LEVEL OF OPTIMIZATION

4. CRITERIA FOR CHOICE

    (FIXED BUDGET) (FIXED BENEFIT) (MATRIX)

5. RECOMMENDATIONS
6. DECISION AND IMPLEMENTATION
7. EVALUATION

Slide 12

The problems discussed above can be addressed by an improved capital budgeting methodology. One source of an improved methodogy is that of the time-proved DoD Cost Benefit Methodology. We briefly touch on major aspects of that methodology, using Miser and Quade [12] as a convenient reference.

(1) **Formulate the problem**. This is often a major aspect of a study, as research reveals that the problem as initially stated is often not the real one. Capital budget decisions may appear to be straightforward, but can become very complex in the changing, competitive world. The problem may encompass strategies for the very survival of the firm. Failure to incorporate CALS, or industry versions of prime-subcontractor electronic communication, in future plans, for example, could spell disaster for aerospace firms.

Recently, Chrysler, Ford, and General Motors warned suppliers that they must be equipped with Electronic Data Interchange EDI [13] by summer 1990. EDI permits the prime contractor to communicate with its subcontractors on a computer-to-computer basis, with a great savings in time, money, and accuracy. Purchase orders and daily delivery schedules are major applications for interface. The subcontractors can then electronically move the data into their own design and production systems without keying in the data again.

(2) **Identify alternatives.** Selection of possible means to achieve the ends is involved here. In DoD studies, imaginative solutions are often proposed, in addition to straightforward ones. That situation should prevail in IDMS capital budgeting decisions as well, and plantwide portfolios of equipment should be considered, not just groups of equipment taken individually.

(3) **Predict consequences.** The estimated costs and benefits of each alternative are derived, often with the aid of explicit models that depict relationships among variables and describe the major assumptions of the future context. Firms examining possible IDMS systems should spell out the assumptions about the future, and have cost and benefit models to aid in their estimation.

Cost structures serve to identify areas of resource usage and dollar costs for a given system. Military system cost structures rarely are able to draw upon accounting systems for data, especially for government costs, since government accounting systems are generally oriented to fiduciary accountability and not to costs incurred by weapon system. Consequently, DoD cost/benefit studies overwhelmingly use data obtained by ad hoc searches of databases. The Planning, Programming, Budgeting System (PPBS), for example, provides a large body of soft, non-accounting data of varying degrees of usefulness, particularly in the FYDP documents. This method of data development has resulted in the buildup of a large community of military "cost analysts" found in the various military cost centers and in FFRDCs such as RAND and IDA [14].

IDMS cost structures in industry should, and must, rely on cost accounting systems for data. Much work needs to be done, and is being done, to modernize cost accounting. The CAM-I organization's work, for example, will be briefly discussed later.

One aspect of DoD studies is that of the proper level of optimization. For instance, one can study air defense of ground troops from the viewpoint of a single service, or that of the DoD, or at the national security level. Options and budgets might increase at each level, along with constraints and competitive systems. The individual firm must also choose among levels of departments, divisions, plants, etc., to include local, national, or worldwide competition.

(4) **Criteria for Choice.** In traditional DoD cost/benefit studies, either a **fixed budget** level was assumed, and the choice made of the alternative that offered the most effectiveness (benefits) for that budget, or a **fixed effectiveness** level was assumed, and the alternative that offered the lowest cost to achieve that level of effectiveness was chosen. However, this proved to be too simplistic, and, gradually a **matrix** approach was adapted, especially for non-DoD studies (after PPBS expanded to include much of the federal government.) Costs were measured several ways, benefits were expressed in both tangible and intangible measures, and measures of risk might be included in a matrix presented to the decision-maker.

This evolution in expanding the criteria for choice in cost/benefit studies appears to have an analog in capital budgeting methodology as it has expanded from ROI measures applied to single items of equipment to a cost/benefit (tangible and intangible) matrix for an integrated manufacturing environment.

(5) **Recommendations.** The compilation of relevant data, and its analysis, should result in a set of recommendations for the decision-maker to consider. Industry patterns should be the same, and top management should be involved in the decisions.

(6) **Decision and Implementation.** This process is often more lengthy and difficult to follow in the DoD as recommendations of studies move up the decision ladder, often including the Office of Management and Budget and the Congress. Industry decisions generally have fewer levels to clear, and lines of authority and approval are more obvious.

(7) **Evaluation.** Post-decision follow-up to verify costs and benefits is given lip service in the literature, but, in our opinion, is very difficult to do for most DoD studies. However, industry should have a better opportunity to conduct such evaluations, and CAM-I recommends that a formal procedure be in place.

METHODOLOGY SOURCES

CURRENT RESEARCH FOR ADVANCED MANUFACTURING MANAGEMENT, SUCH AS:

CAMI-I CONCEPTUAL DESIGN COMPONENTS

1. STRATEGIC PLAN - 15 FUNCTIONS
2. COST ACCOUNTING SYSTEM
3. INVESTMENT MANAGEMENT METHODOLOGY

Slide 13

Another source of an improved methodology for capital budgeting decisions for advanced technology is the recent CAM-I investment methodology [15]. The methodology is part of a comprehensive design for firms undertaking to evaluate and utilize advanced technology. Three major components of their conceptual design are:

(1) A strategic plan, including 15 functions that the firm uses for planning and operation

(2) A cost accounting system

(3) An investment methodology.

These will be discussed briefly.

CAM-I FUNCTIONS

1. STRATEGIC PLANNING
2. BASIC R&D
3. MARKETING
4. PRODUCT/PROCESS DEVELOPMENT AND MAINTENANCE
5. TOOLING AND PRODUCTION PROGRAMMING
6. PRODUCTION MANAGEMENT
7. IN-PROCESS MATERIAL MOVEMENT
8. PRODUCTION OPERATIONS
9. INCOMING MATERIAL CONTROL
10. OUTGOING MATERIAL CONTROL
11. PRODUCTION QUALITY CONTROL
12. HUMAN RESOURCES
13. INFORMATION SYSTEMS
14. FACILITIES MANAGEMENT
15. PRODUCT SERVICES

Slide 14

CAM-I recommends that a firm evaluate its activities according to 15 functions. These functions will be described in more detail later. The first function, Strategic Planning, is of extreme importance, as it includes 5- to 10-year forecasts of the firm's products and product mix, competitive strategies, and financial constraints.

CAM-I COST ACCOUNTING SYSTEM

- COST CENTERS BY MACHINE GROUP
- COSTS BY ACTIVITY
- ALLOCATE COSTS ON MACHINE-MINUTES
- LABOR, MATERIAL TECHNOLOGY COSTS, OVERHEAD
- NON-VALUE-ADDED COST IDENTIFIED (MOVE, STORE, INSPECT, REWORK)
- LIFE-CYCLE COST BY PRODUCT

Slide 15

The CAM-I accounting system recommendations (which are still being tested and are not yet proven) can only be discussed briefly in this context. Emphasis is placed upon:

(1) **Cost Centers** by organization, but oriented around machine centers, either individual machines, such as numerically controlled machines, or groups of machines, such as flexible machining cells, or processes or assembly lines. Costs, by cost element, are accumulated by each cost center.

(2) **Cost by Activity.** An activity is some operation or function that can be measured, such as milling, welding, etc. Costs are collected by part number by activity.

(3) **Cost Allocation by Machine-Minutes.** Time is reported by activity and cost center costs are allocated to activity time on a machine-minute basis. This replaces today's cost allocation system, which generally uses direct-labor dollars to allocate large pools of indirect costs to parts.

(4) **Cost Elements** of direct labor, direct material, technology costs (depreciation and other machine-related costs), and overhead are assigned to each cost center.

(5) **Non-Value-Added Costs** are identified and separately accounted for, if possible. These costs are costs to move, store, inspect, and rework. Value-added costs involve processing of a part.

(6) **Life-Cycle Costs by Product** are to be accumulated for analysis, pricing, etc. The suggested life-cycle phases for the firm are:

- Design and development
- Production
- Product support.

CAM-I INVESTMENT MANAGEMENT SYSTEM

1. EXTRACT INFORMATION FROM THE STRATEGIC PLAN: MARKET SHARE, REVENUE GROWTH PROFITABILITY AS TRANSLATED INTO TARGETS FOR COST, QUALITY, FLEXIBILITY, THROUGHPUT, DELIVERY, AND RESPONSIVENESS
   PRODUCT FORECASTS
   COMPETITIVE STRATEGIES

2. ESTIMATE LIFE-CYCLE COSTS
   ENGINEERING, MANUFACTURING, AND LOGISTICS SUPPORT
   BY PRODUCT LINE BY EACH OF 15 FUNCTIONS

3. ESTABLISH PERFORMANCE TARGETS
   PRODUCT COST, QUALITY, THROUGHPUT, AND FLEXIBILITY

4. IDENTIFY CANDIDATE TECHNOLOGIES

5. ANALYZE RISKS OF CANDIDATE TECHNOLOGIES
   ECONOMIC, TECHNOLOGICAL AND HUMAN RESOURCE IMPLEMENTATION

6. EVALUATE ALTERNATIVE INVESTMENT OPPORTUNITIES
   USE TRADITIONAL ROI, NPV PLUS QUALITATIVE MEASURES, WEIGHTED MATRIX

7. SELECT AN INVESTMENT PORTFOLIO
   CAPTURE TECHNOLOGICAL SYNERGIES, SCHEDULE CONSIDERATIONS AND PROJECT ACTIVITIES BY FOCUS ON THE WHOLE

8. ESTABLISH A COST-BENEFIT TRACKING SYSTEM
   ("COST BENEFIT" IS USED HERE IN A NARROW MEANING)

Source: Ref [15]

Slide 16

CAM-I has designed an investment management system for evaluation of advanced technologies. The eight-step process is very similar to the DoD cost/benefit methodology. These steps will be discussed next as we look at an IDA-recommended IDMS methodology.

SUMMARY COMPARISON OF DoD and RECOMMENDED IDMSS COST/BENEFIT METHODOLOGY

DoD	RECOMMENDED IDMSS
1. FORMULATE PROBLEM	1. DEVELOP STRATEGIC PLAN
2. IDENTIFY ALTERNATIVES	2. IDENTIFY CANDIDATE TECHNOLOGIES
3. PREDICT CONSEQUENCES	3. PREDICT CONSEQUENCES
FUTURE CONTEXT	DYNAMIC, NOT STATUS QUO
COSTS	LIFE-CYCLE COSTS; COST STRUCTURES
BENEFITS	INCLUDE INTANGIBLE BENEFITS
LEVEL OF OPTIMIZATION	PLANTWIDE, INDUSTRY-WIDE
4. CRITERIA FOR CHOICE	4. CRITERIA FOR CHOICE
FIXED BUDGET; FIXED EFFECTIVENESS; MATRIX	MATRIX OF COSTS, TANGIBLE AND INTANGIBLE BENEFITS, ECONOMIC MEASURES
5. RECOMMENDATIONS	5. PORTFOLIO SELECTION
6. DECISION AND IMPLEMENTATION	6. DECISION AND IMPLEMENTATION
7. EVALUATION	7. COST-BENEFIT TRACKING

Slide 17

IDA has combined the proven features of DoD's cost/benefit methodology with that of the CAM-I investment methodology to recommend an IDMS Cost/Benefit Methodology. Brief comments on the seven recommended steps follow:

(1) **Strategic Plan.** The importance of this step cannot be overemphasized. The future world of competition and of government requirements must be taken into account, and the status quo cannot be assumed to prevail. Firms must explicitly plan a strategy for survival in an era of rapidly evolving high technology. Defense contractors at every level, prime or sub, will face severe problems, for example, if they fail to plan for the CALS environment of the 1990s. Likewise, firms doing commercial business must take EDI (Electronic Data Interchange) into account.

(2) **Candidate Technologies.** Firms need to examine the full complement of proposed equipment in order to understand their synergistic effects, flexibility, etc. Piecemeal consideration will not do.

(3) **Predict Consequences.** As noted above, a dynamic view of the future must be considered in models that are used to estimate costs and benefits. Cost structures and benefit structures that highlight IDMS system features should be used in preparing estimates. Benefit structures should elicit consideration of intangible as well as tangible benefits. A company-wide view needs to be taken and the industry-wide context should also be considered.

(4) **Criteria for Choice.** Corporate decision-makers should be provided with a matrix of costs, economic measures, and tangible and intangible benefits for each alternative investment package. Emphasis should not be placed upon a single measure such as ROI.

(5) **Portfolio Selection**. A portfolio of investment opportunities should be selected for consideration, given the full picture of benefits and costs in the context of a dynamic enviroment.

(6) **Decision and Implementation**. Investment decisions, once made, should be followed up as to their actual costs and benefits.

(7) **Cost/Benefit Tracking**. The CAM-I methodology calls for an explicit cost/benefit tracking system to be implemented in a firm.

COST/BENEFIT STRUCTURES

- INDUSTRY COST STRUCTURES
- RECOMMENDED COST/BENEFIT STRUCTURE

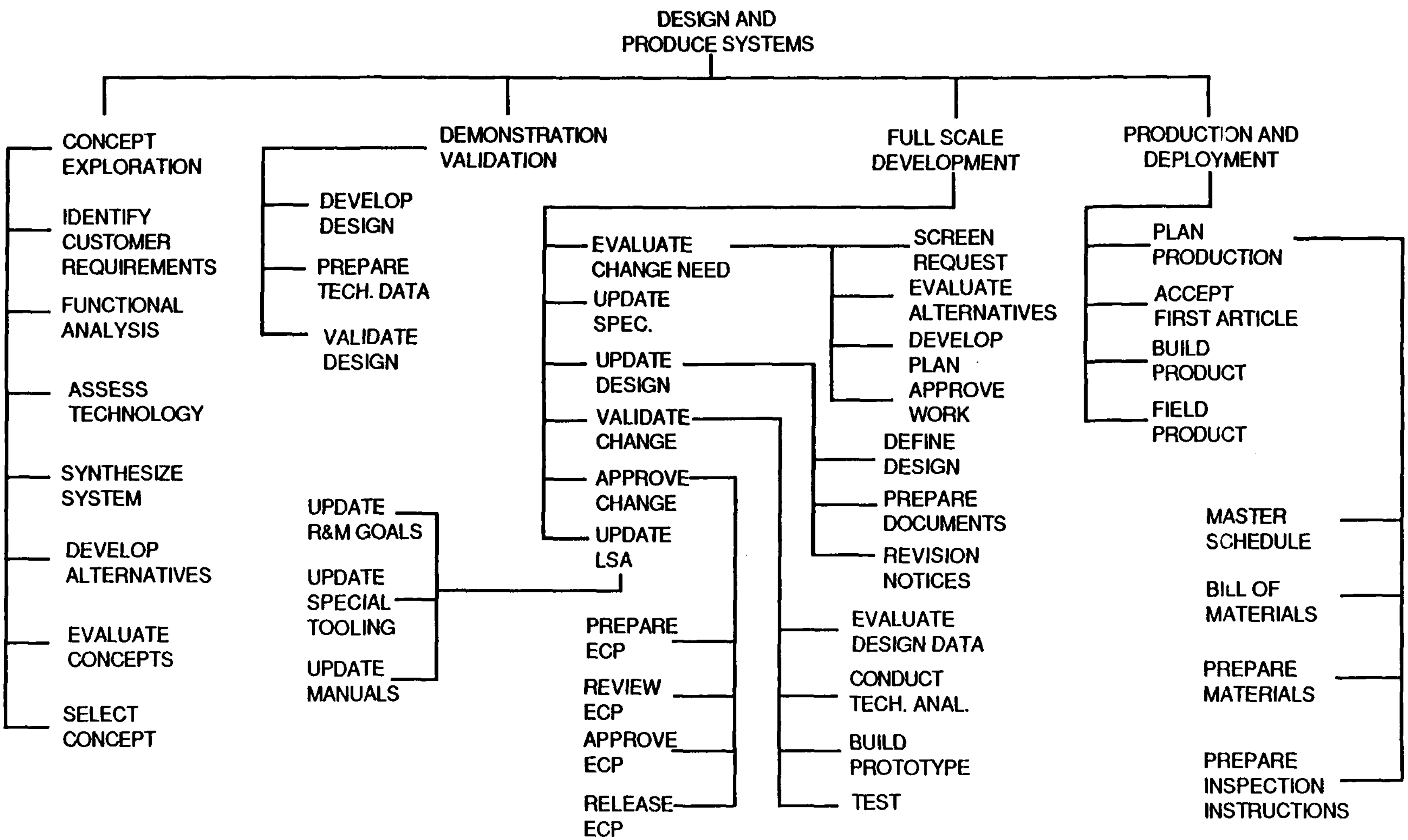
Cost/Benefit Structures

Slide 18

As experience has been gained in the introduction of integrated systems, a concern has been expressed about the cost structures used by industry in evaluating and accounting for the costs and benefits of those systems. Current industry practice tends to collect and report costs as a function of direct-labor hours. The costs associated with developing, installing, and operating automated, integrated systems are usually reported as overhead costs and are allocated to various cost centers based on direct-labor input. As design and production become more oriented toward computer-aided activities, current practices tend to distort the product's unit cost. This can lead to improper pricing and incorrect investment decisions. Therefore, we looked at ongoing attempts to develop cost structures that would be more compatible with integrated data systems and with cost/benefit methodology.

We found no benefit structures in our industry review.

COST STRUCTURE: COMPANY A

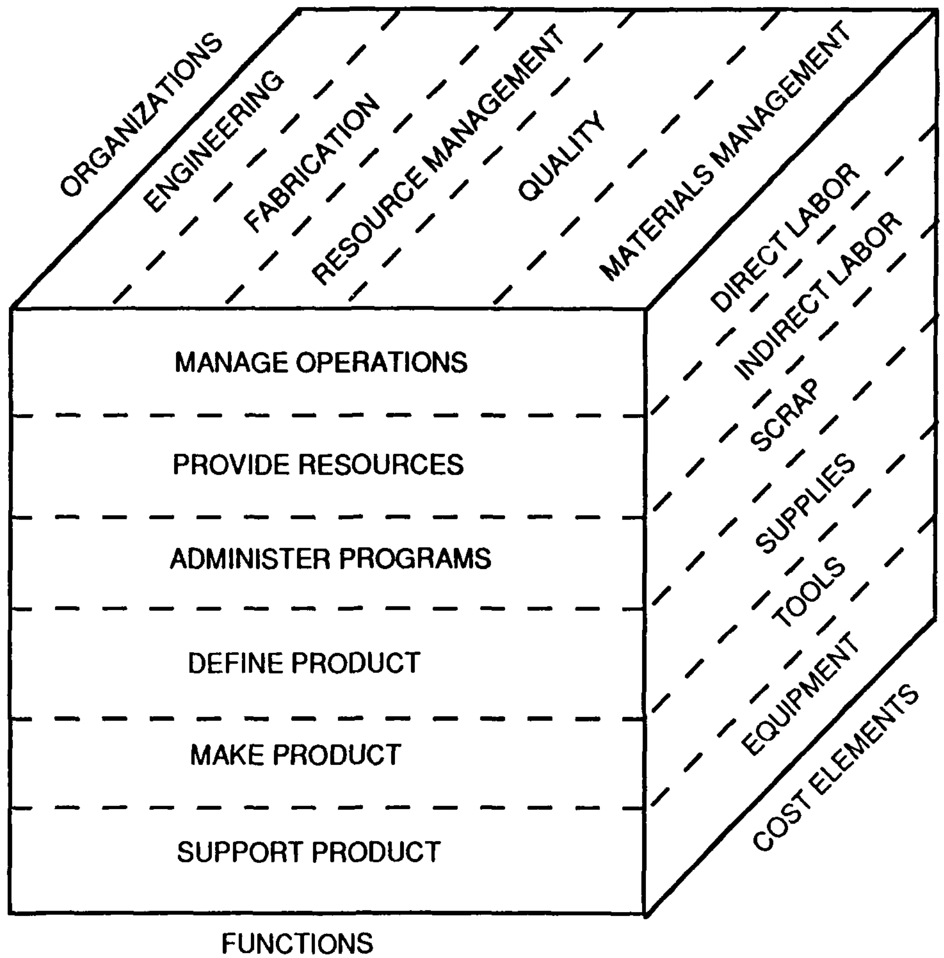


Slide 19

Three companies were willing to share the results of their analyses and development of a new functional cost structure. Each of the companies was at a different stage in their development process.

Company A has just started the process. It has a first draft of a functional breakdown of the design and production process.

COST STRUCTURE: COMPANY B



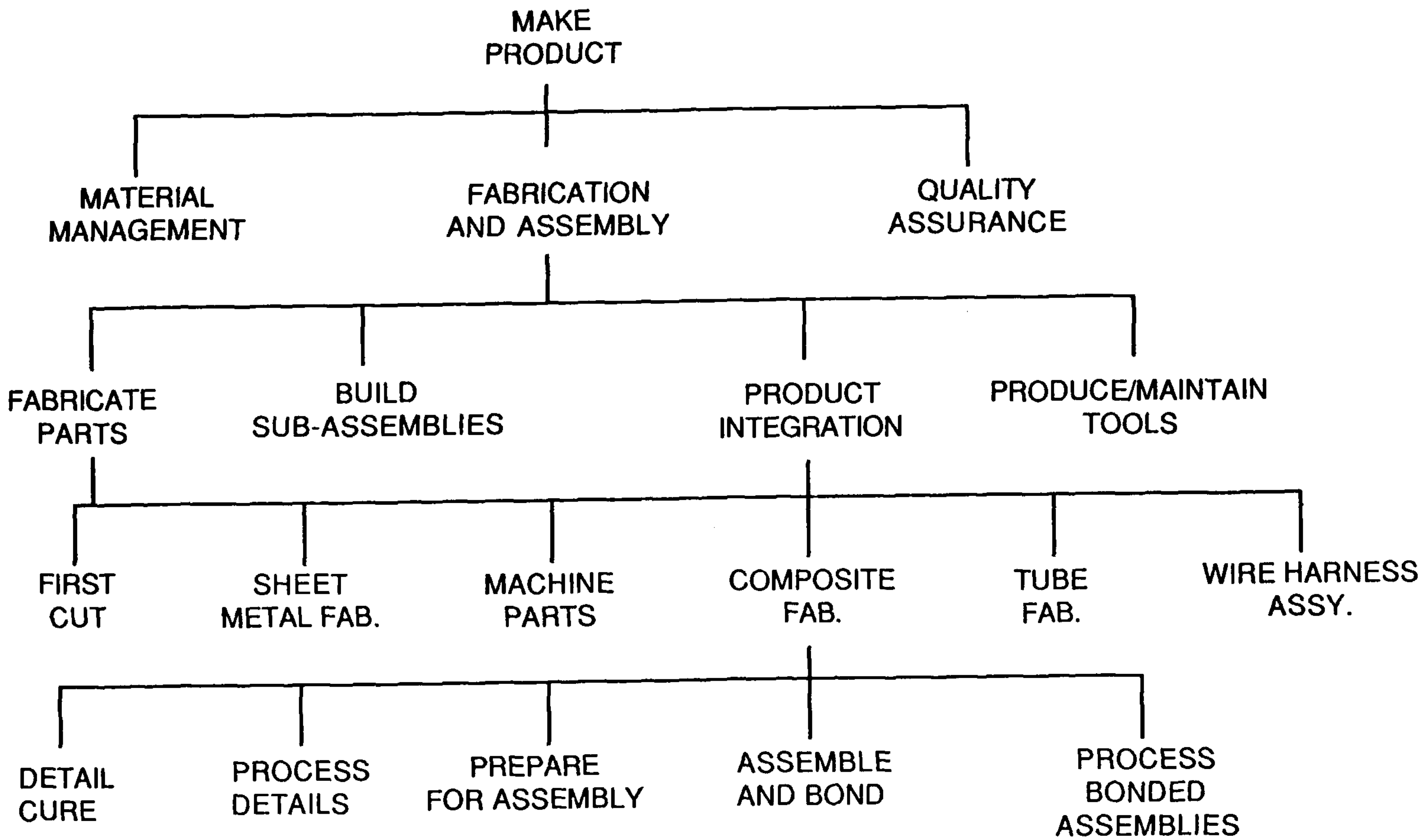
REPEAT STRUCTURE BY PROGRAM
AND BY YEAR

Slide 20

Company B is much farther along in structure development. They have developed a structure identifying the major cost elements and organizational groupings as well as the functions. The functions shown on the slide have been further subdivided to at least the fifth tier. We have no indication of any further breakdown of the organization and element structures. File information also indicates that Company B attempted to apply this structure to their current product lines. However, the resulting disruptions to current product costs stopped further experimentation.

COST STRUCTURE: COMPANY B

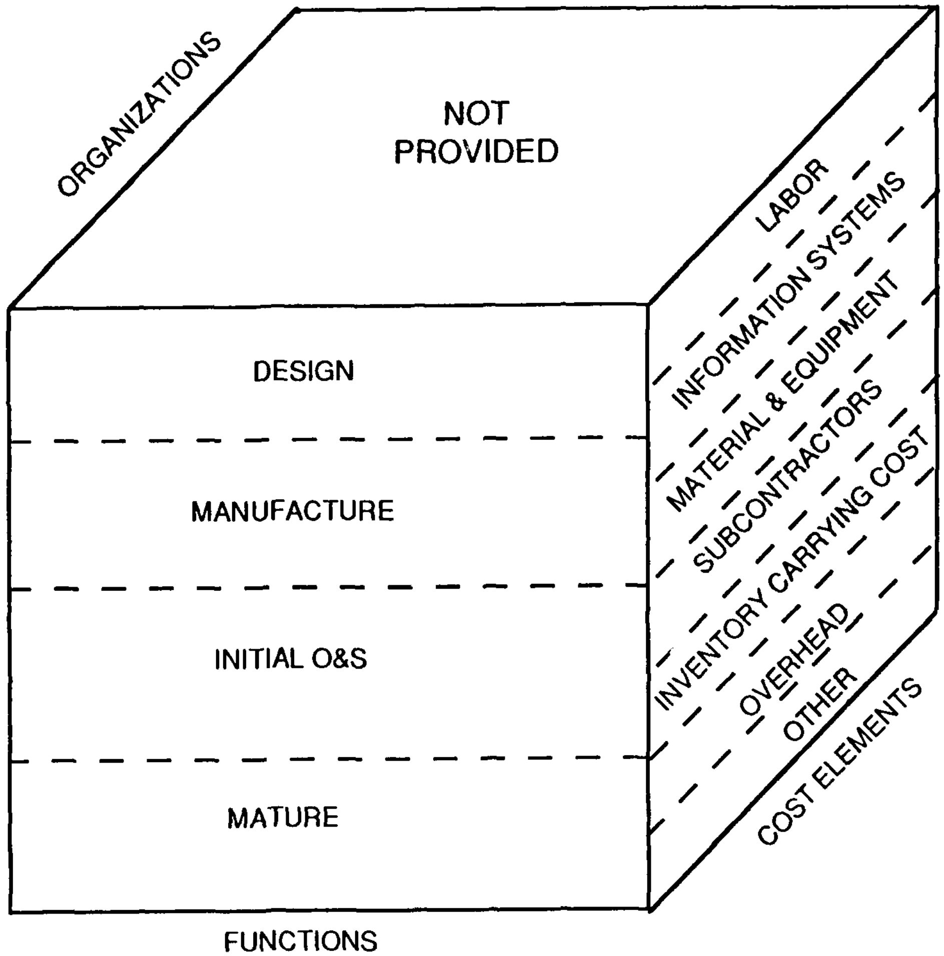
EXAMPLE OF A FUNCTIONAL TRAIL



Slide 21

This is an example of the breakdown of the production function developed by Company B. Only one path is shown to the fifth tier. Each of the other categories in the second, third, and fourth tiers would be subdivided as appropriate.

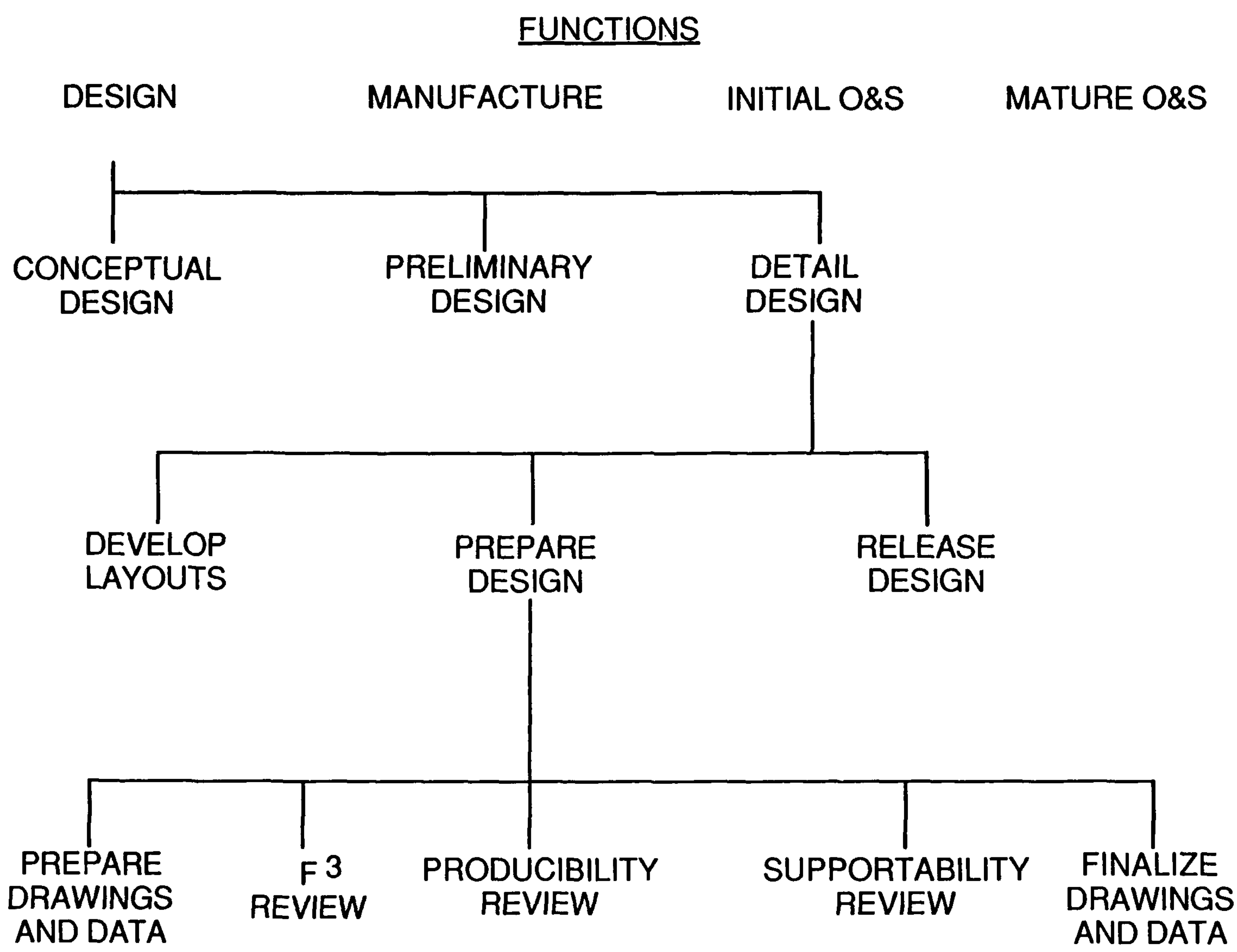
COST STRUCTURE: COMPANY C



Slide 22

Company C has also developed a functional cost structure. We were not able to identify an organizational stucture in the material provided to us. The cost element listing did not indicate any further division of cost categories. However, a rather detailed breakdown of functions was provided through the fifth tier for all of the functions shown.

COST STRUCTURE: COMPANY C



Slide 23

An example of one trail through Company C's functional breakdown is shown here.

Each of the three examples represent the beginnings of a functional evaluation of a company's activities. They were prepared by individuals involved in product design and manufacturing and that orientation is reflected in the structures. Although Company B includes a category for operational management, none of the structures reflect the scope of corporate management, financial operations, marketing, etc. However, they do indicate that a number of individuals and groups recognize the problem and are taking positive steps to find a solution.

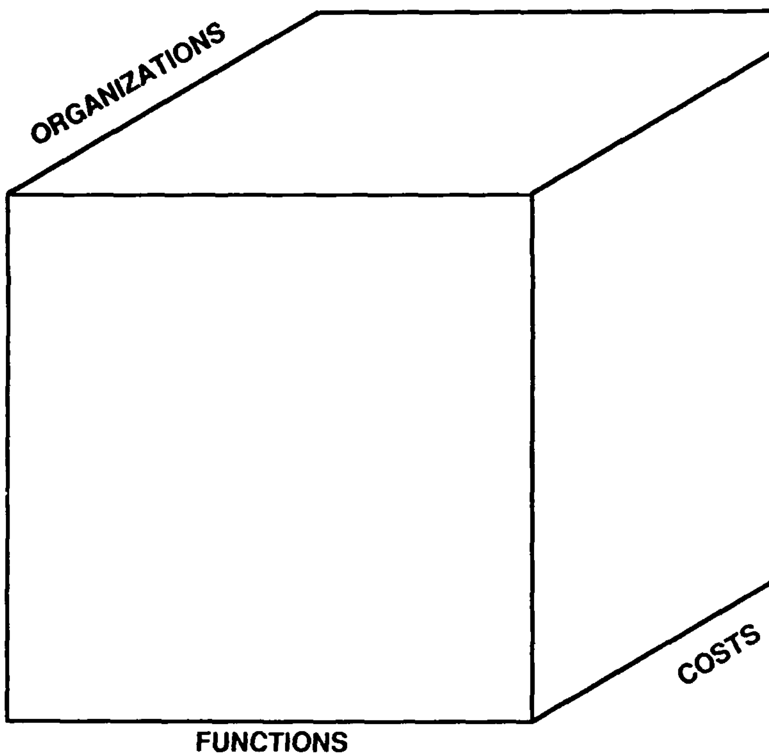
RECOMMENDED COST/BENEFIT STRUCTURE (AIRCRAFT SYSTEMS)

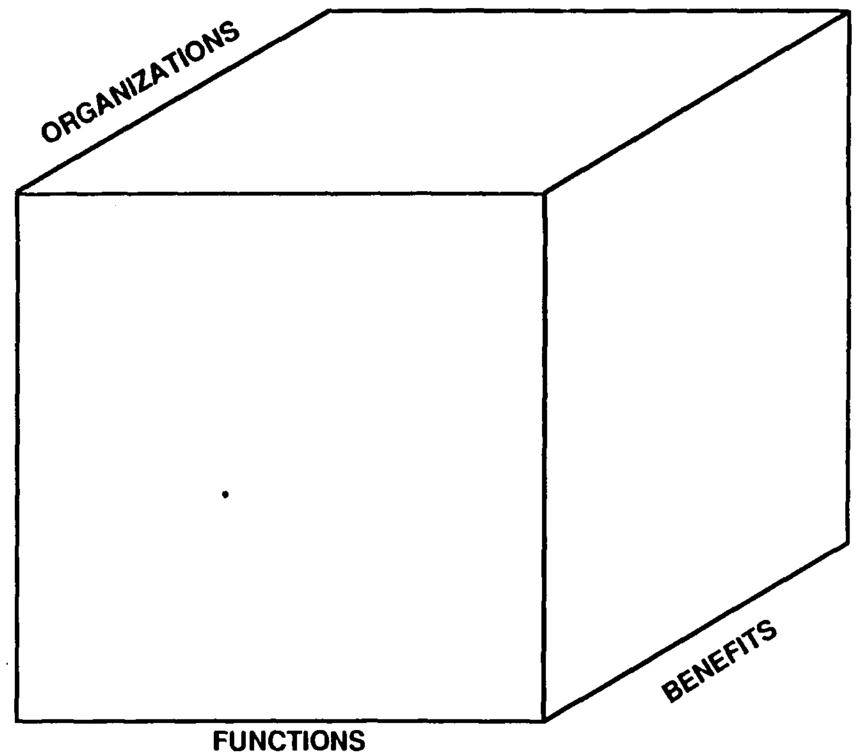
- OVERVIEW
- ORGANIZATIONS
- FUNCTIONS
- RESOURCE AND COST ELEMENTS
- BENEFITS

Slide 24

We have reviewed the current efforts to develop a functional cost breakdown structure in the light of the CAM-I work [15] and cost/benefit methodology. The following vugraphs present our proposal for a "strawman" structure. It should be noted that, as with any generalized structure, application would require modification to fit the company and the product line. This structure is submitted as a possible starting point for further analysis.

COST/BENEFIT STRUCTURE OVERVIEW





Slide 25

The proposed structure is a dual one covering costs and benefits. The reason for separating the cost and benefit structure is to provide a vehicle for estimating qualitative benefits. Each of the surfaces would be subdivided to reflect the specific company's organization and activities.

CONTRACTOR ORGANIZATION

- ENGINEERING
- MANUFACTURING
- MATERIAL ACQUISITION AND HANDLING
- FIELD SUPPORT
- GENERAL AND ADMINISTRATIVE

(DETAIL WITHIN EACH ORGANIZATION AS APPROPRIATE)

Slide 26

A basic organization for an aerospace defense contractor is depicted. The structure should be modified to match each specific firm's organization and detail should be added, as appropriate.

IDA-RECOMMENDED LIST OF IDMSS FUNCTIONS - SUMMARY

AEROSPACE FIRM - AIRCRAFT SYSTEMS
(DRAWN FROM CAM-I AND INDUSTRY LISTS)

1. STRATEGIC PLANNING
2. MARKETING
3. BASIC R&D
4. AIRCRAFT SYSTEM DESIGN AND DEVELOPMENT
5. PRODUCTION MANAGEMENT
6. INCOMING MATERIAL CONTROL
7. PRODUCTION OPERATIONS
8. IN-PROCESS MATERIAL MOVEMENT
9. PRODUCTION QUALITY CONTROL
10. ENGINEERING SUPPORT OF MANUFACTURING
11 OUTGOING MATERIAL CONTROL
12. HUMAN RESOURCES
13. INFORMATION SYSTEMS/FINANCIAL MANAGEMENT
14. FACILITIES MANAGEMENT
15. LOGISTICS, TRAINING, AND MAINTENANCE SUPPORT

Slide 27

The recommended list of functions at the first level of indenture is primarily that of CAM-I, modified by the details provided by Company B for its CALS cost/benefit cost structure.

IDA-RECOMMENDED LIST OF IDMSS FUNCTIONS - PARTIAL DETAIL AEROSPACE FIRM - AIRCRAFT SYSTEMS (DRAWN FROM CAM-I AND INDUSTRY LISTS)

FUNCTION

1. STRATEGIC PLANNING
   A. DEVELOP LONG-RANGE PRODUCT FORECAST (5-10) YEARS
   B. FORMULATE COMPETITIVE STRATEGIES
   C. DEVELOP FINANCIAL CONSTRAINTS
2. MARKETING
   A. CONDUCT MARKET RESEARCH
   B. DEVELOP PRICING
   C. PREPARE SHORT-RANGE SALES FORECASTS
   D. DEVELOP MASTER PRODUCTION SCHEDULE REQUIREMENTS
3. BASIC R&D
   A. CONDUCT INDEPENDENT RESEARCH & DEVELOPMENT
   B. PREPARE BIDS & PROPOSALS
4. AIRCRAFT SYSTEM DESIGN AND DEVELOPMENT
   A. DESIGN
      1. CONCEPTUAL DESIGN
         a. CONDUCT RESEARCH
         b. ANALYZE CUSTOMER REQUIREMENTS
         c. FORMULATE CONCEPTS
            1. DEVELOP PRODUCT CONCEPTS
            2. PERFORM INTERDISCIPLINARY STUDIES
         d. SELECT CANDIDATE CONFIGURATIONS
      2. PRELIMINARY DESIGN

---

15. LOGISTICS, TRAINING & MAINTENANCE SUPPORT
   A. INITIAL DEPLOYMENT AND EARLY OPERATIONS
   B. FULL DEPLOYMENT AND MATURE OPERATIONS

Slide 28

Each function has been subdivided into as many as five levels, as shown on this sample display of the detail. A full listing is given in Table 1. The detail follows that of an aircraft manufacturer and emphasis is on logistical and training support. CALS interface areas of design (engineering drawings), manufacture (drawings and ECPs), logistics (spares provisioning), and training (training manuals) are covered in this structure, but not always as explicitly as they will be in future versions. The detail, however, approximates that of the contractor whose structure was specifically designed for a CALS cost/benefit study.

Table 1. IDA-Recommended List of IDMS Functions
Aerospace Firm - Aircraft Systems
(Drawn from CAM-I and Industry Lists)

1. Strategic Planning
    - A. Develop long-range product forecast (5-10 years)
    - B. Formulate competitive strategies
    - C. Develop financial constraints
2. Marketing
    - A. Conduct market research
    - B. Develop pricing
    - C. Prepare short-range sales forecasts
    - D. Develop master production schedule requirements
3. Basic R&D
    - A. Conduct independent research & development
    - B. Prepare bid & proposals
4. Aircraft System Design and Development
    - A. Design
        1. Conceptual design

Table 1. IDA-Recommended List of IDMS Functions (Continued)

            a. conduct research
            b. analyze customer requirements
            c. formulate concepts
                1. develop product concepts
                2. perform interdisciplinary studies
            d. select candidate configurations
        2. Preliminary design
        3. Estimate costs, make budgets
        4. Monitor performance

    B. Plan production

        1. Control planning
        2. Determine detailed method of manufacturing
        3. Develop production instructions
        4. Program tooling

    C. Provide production resources

        1. Facilities
        2. Equipment
        3. Tools

5. Incoming Material Control

    A. Control procurement of materials
    B. Procure materials
    C. Inspect materials
    D. Move to manufacturing storage area
    E. Manage materials inventory

6. Production Operations

    A. Control production orders
    B. Control production items and tools
    C. Perform physical production

Table 1. IDA-Recommended List of IDMS Functions (Continued)

7. In-Process Material Movement
   - A. Move and store WIP
8. Production Quality Control
   - A. Inspect, test, and checkout
9. Engineering Support of Manufacturing
   - A. Negotiate schedule of manufacturing
   - B. Evaluate requests for drawing changes
   - C. Review, select material substitution
   - D. Perform material review
     1. Review the non-conformance
     2. Determine repair disposition
     3. Review cause/corrective action
     4. Answer per disposition manual
     5. *Determine, write non-standard repair*
     6. Prepare, update standard disposition manual
   - E. Perform liaison engineering
     1. Monitor product manufacture
     2. Provide technical assistance
     3. Analyze engineering squawk book
10. Outgoing Material Control
    - A. Move aircraft to flight test
    - B. Deliver aircraft to customer for flight test
11. Human Resources
    - A. Personnel management
    - B. Employee training administration
    - C. Compensation management
    - D. Benefit administration

Table 1. IDA-Recommended List of IDMS Functions (Continued)

12. Information Systems/Financial Management
    - A. Design information systems -- other than program management
    - B. Implement systems
    - C. Perform financial management
        1. Perform accounts receivable function
        2. Perform other accounting functions

13. Facilities Management
    - A. Perform maintenance
    - B. Perform security
    - C. Manage energy
    - D. Perform plant rearrangement

14. Logistics, Training & Maintenance Support
    - A. Initial deployment and early operations
        1. Support verification, deployment of product
            - a. provide test engineering support
                1. develop tests
                2. structural lab tests
                3. dynamic tests
                4. certify instrumentation calibration
                5. document test results
            - b. provide pre-flight checkout support
            - c. provide flight test support
            - d. provide acceptance test support
        2. *Support product operations*
            - a. perform force management
            - b. provide pre-deployment logistics support
                1. provide interface analysis support
                2. assist acquisition/training services
                3. assist support equipment design

Table 1. IDA-Recommended List of IDMS Functions (Continued)

- c. support depot activities
  - 1. provide field operations support
    - a. acquire, train personnel
    - b. operate/support aircraft at unit level
    - c. maintain aircraft in the field
  - 2. provide support/supervision services
  - 3. perform depot engineering activities
    - a. support depot-level repair activity
    - b. support depot maintenance and model activity
    - c. support design/use of additional equipment
    - d. perform inspection operations
    - e. perform readiness/support operations
    - f. perform survivability engineering
  - 4. provide subcontractor acquisition support
- 3. Support product update/modification
  - a. establish requirements
    - 1. evaluate field problems
    - 2. determine modification review dispositions
    - 3. evaluate alternative systems
    - 4. develop engineering change proposals
    - 5. evaluate mission change requirement
    - 6. review lessons learned
  - b. develop designs
  - c. support manufacturing
    - 1. negotiate schedule change points
    - 2. perform approved changes
    - 3. review material substitution for changes
    - 4. perform liaison engineering

- B. Full Deployment and Mature Operations
  - 1. Provide engineering support of manufacturing
  - 2. Support verification, deployment of product

Table 1. IDA-Recommended List of IDMS Functions (Continued)

3. Support product operations
    a. perform force management
    b. provide post-deployment logistics support
    c. support depot activities
        1. provide field operations support
            a. acquire, train personnel
            b. operate/support aircraft at unit level
            c. maintain aircraft in the field
        2. provide support/supervision services
        3. perform depot engineering activities
            a. support depot-level repair activity
            b. support depot maintenance and modification activity
            c. support design/use of additional equipment
            d. perform inspection operations
            e. perform readiness/support operations
            f. perform suvivability engineering
        4. provide subcontractor acquisition support
4. Support product update/modification
    a. establish requirements
        1. evaluate field problems
        2. determine modification review dispositions
        3. evaluate alternative systems
        4. develop engineer change proposals
        5. evaluate mission change requirement
        6. review lessons learned
    b. develop designs
    c. support manufacturer
        1. negotiate schedule change points
        2. perform approved changes
        3. review material substitution for changes
        4. perform liaison engineering
    d. validate prototype/proof kit testing
    e. support retrofit of update or modification

RESOURCES PART OF COST STRUCTURE

	AS IS	TO BE	INCREMENTAL COST
I. RESOURCES:			
A. PERSONNEL (AVE. MAN-YEARS)			
1. DIRECT			
2. INDIRECT			
TOTAL			
(ESTIMATE BY FUNCTION BY ORGANIZATION)	XXX	XXX	XXX

B. LAND AND FACILITIES
(IDENTIFY AND EST. SQUARE FOOTAGE)
1. ENGINEERING
2. MANUFACTURING
3. TEST
4. STORAGE/MAINTENANCE
5. FIELD SITES
6. GENERAL & ADMINISTRATIVE

C. EQUIPMENT
1. SPECIAL PURPOSE COMPUTERS (EX DESIGN)
2. SOFT TOOLING & TEST
3. PRODUCTION TOOLING
4. PRODUCTION MACHINERY
5. PROCESS CONTROL COMPUTERS
6. INSPECTION
7. STORAGE AND HANDLING
8. AUTOS, TRUCK, AIRPLANES
9. FURNITURE AND FIXTURES

D. SOFTWARE
(INDICATE IF CALS SPECIFICATION MET)
1. COMPUTER-AIDED DESIGN
2. COMPUTER-AIDED MANUFACTURING
3. ACCOUNTING
4. GENERAL PURPOSE
5. INTEGRATED LOGISTICS SUPPORT
6. PUBLICATONS

Slide 29

The estimation of resources required by an IDMS system is aided by a cost structure as recommended here. **Personnel** should be estimated in average man-years (not headcount) by direct and indirect categories by function within each organization. **Land and Facilities** should be estimated for the indicated activities. The list of functions will aid as a check in ensuring that all required facilities are included. **Equipment** should, likewise, be estimated by capitalization category, using the list of functions as a checklist. **Software** should be estimated by major application, and whether CALS specifications have been met by the software should be indicated.

We note on the table that there are three columns, "As Is," "To Be," and "Incremental Cost" (or the difference). The incremental cost will vary widely from firm to firm (and, of course, from forecast to forecast within a firm) as IDMS equipment and software are put in place. The incremental cost to achieve a CALS capability in, say, engineering design, may be quite modest for a company with a powerful CAD package in place. The incremental cost for a small subcontractor to achieve the same capability could be quite large if he is starting from scratch. Each situation will be different. As a firm evolves in its introduction of IDMS technology, its incremental cost to achieve the next level of capability will decrease.

DOLLAR COST PART OF COST STRUCTURE

II. CAPITAL COSTS

	AS IS	TO BE	INCREMENTAL COST
A. LAND AND FACILITIES			
B. EQUIPMENT			
C. SOFTWARE	XXX	XXX	XXX

III. PROGRAM/PRODUCT COSTS
- A. LIFE-CYCLE PHASE
  (*ESTIMATE BY COST ELEMENT BY FISCAL YEAR)*
  1. DESIGN AND DEVELOPMENT
  2. PRODUCTION
  3. LOGISTICS/TRAINING SUPPORT

- B. COST ELEMENT
  1. DIRECT COSTS
     - A. DIRECT LABOR
     - B. DIRECT FRINGES (IF APPLICABLE)
     - C. DIRECT MATERIAL
     - D. INTRA-COMPANY WORK ORDERS
     - E. SUBCONTRACTS
     - F. OTHER DIRECT COSTS

  2. INDIRECT COSTS
     (ASSIGN TO PROGRAM/PRODUCT BY BURDEN CENTER RATE)
     (COMPUTE PLANTWIDE OVERHEAD BY BURDEN CENTER):
     - A. ENGINEERING
     - B. MANUFACTURING
     - C. MATERIAL
     - D. FIELD SUPPORT
     - E. GENERAL AND ADMINISTRATIVE

Slide 30

The resources identified above as required for the IDMS system must be translated into dollar costs as shown on this structure. **Capital costs** must be estimated separately from **Program/Product costs**. The "As Is," "To Be," and "Incremental Cost" format should be used. Assign overhead costs to product costs using burden center rates, but examine overhead very closely.

COST ACCOUNTS FOR BURDEN CENTER ESTIMATES

	AS IS	TO BE	INCREMENTAL COST
A. INDIRECT LABOR			
1. SALARIES AND WAGES - INDIRECT PERSONNEL			
2. OVERTIME AND BONUSES			
3. INDIRECT TIME - DIRECT PERSONNEL	XXX	XXX	XXX
B. FRINGE BENEFITS			
1. GROUP INSURANCE			
2. RETIREMENT PLANS			
3. VACATION AND HOLIDAY PAY			
4. SICK LEAVE AND MISC. LEAVE			
5. PAYROLL TAXES			
6. WORKMEN'S COMPENSATION			
7. OTHER FRINGES			
C. FACILITIES-RELATED COSTS			
1. UTILITIES			
2. DEPRECIATION			
3. RENT			
4. INSURANCE			
5. TAXES			
6. MAINTENANCE			
D. DATA PROCESSING COST			
1. EQUIPMENT RENTAL AND MAINTENANCE			
2. SOFTWARE			
E. CORPORATE OFFICE ALLOCATION			
F. IR&D/B&P			
G. OTHER EXPENSE			
1. TRAVEL			
2. COMMUNICATIONS			
3. FREIGHT AND TRANSPORTATION			
4. SUPPLIES			
5. TOOLS			
6. LEGAL AND PROFESSIONAL			
7. OTHER			
H. CREDITS			
1. SCRAP SALES			
2. OTHER CREDITS			

Slide 31

Indirect, or overhead, costs should be estimated by burden center based upon a buildup by function. The recommended chart of accounts is based upon IDA's in-depth studies of the indirect costs of 11 major aerospace contractors. Obviously, some overhead elements, such as Fringe Benefits, will not vary as a function of IDMS equipment.

BENEFITS

	AS IS	TO BE	INCREMENTAL BENEFIT
1. TANGIBLE:			
REDUCTION IN ENGINEERING DESIGN TIME			
REDUCTION IN TRANSIT AND STORAGE TIME			
REDUCTION IN MANUFACTURING LEAD TIMES	XXX	XXX	XXX
REDUCTION IN INVENTORIES:			
PARTS AND RAW MATERIAL			
WORK-IN-PROCESS			
FINISHED GOODS			
REDUCTION IN DIRECT LABOR:			
SETUP TIME			
OPERATIONS TIME			
REWORK TIME			
REDUCTION IN FACILITIES SPACE			
REDUCTION IN SCRAP RATES			
REDUCTION IN INDIRECT LABOR:			
INSPECTION TIME			
WORK TRACKING TIME			
TRANSPORTATION TIME			
TOOL CONTROL TIME			
SCHEDULING/PRODUCTION CONTROL TIME			
OPERATOR TRAINING TIME			
REDUCTION IN RESPONSE TIME TO CUSTOMER ORDERS			

2. INTANGIBLE:

COMPETITIVE POSITION IMPROVED
FIRM SURVIVIBILITY INCREASES
GREATER MANUFACTURING FLEXIBILITY
INTEGRATION OF DESIGN, PROCESS PLANNING AND MFG.
STANDARDIZATION BENEFITS, DESIGN NONPROLIFERATION
IMPROVED PRODUCT QUALITY, RELIABILITY, MAINTAINABILITY

Slide 32

The structure recommended for the estimation of benefits is divided into sections for **tangible benefits and intangible benefits.** The "reduction" is of course the value of the "Incremental Benefit" column and not the "As Is" or "To Be" columns, which contain total values. Time estimates and reductions in inventory must be converted into dollar estimates, but separate columns are not depicted here for the sake of brevity.

INTEGRATION OF COST AND BENEFIT STRUCTURES INTO IDMSS METHODOLOGY

METHODOLOGY STEP	AS IS	TO BE	INCREMENTAL COST OR BENEFIT
3. PREDICTING CONSEQUENCES:	XXX	XXX	XXX
RESOURCES	XXX	XXX	XXX
DOLLAR COSTS	XXX	XXX	XXX

4. CRITERIA FOR CHOICE:
   COMPILE FROM ABOVE MATRIX OF COSTS AND BENEFITS
   COMPUTE ROI AND OTHER ECONOMIC MEASURES

Slide 33

To close this discussion of cost and benefit structures, let us review their relationship to the cost/benefit methodology recommended earlier. In that IDMS methodology, step 3 was Predicting Consequences and Step 4 was Criteria for Choice. The costs in resources and dollars would be estimated using the cost structure tables, while the benefits would be estimated from the benefit structure table. Then, these estimates would be compiled into a matrix displaying both costs and benefits, together with the various economic measures that have been selected for computation.

TASK 3: INFORMATION SYSTEM SAVINGS

- NO SPECIFIC IDMS COST/BENEFIT STUDIES FOUND
- SELECTED COSTS FROM SURVEY
- SELECTED BENEFITS FROM SURVEY

TASK 3: INFORMATION SYSTEM SAVINGS

Slide 34

Our third task was to determine the extent of potential savings from application of IDMS technology and review industry cost/benefit studies. We did not find any specific examples of industry cost/benefit studies. Although there were some allusions to internal evaluations performed by some companies, they were considered proprietary and not discussed. However, a number of comments were received concerning the strategic nature of the decisions to implement IDMS systems.

A number of examples of costs and benefits were found in the literature, although not presented together. The next three charts summarize the information we found.

SELECTED COSTS

- **INTEGRATING DATABASES FOR LOGISTICS SUPPORT OF MAJOR AIRCRAFT SYSTEM**

  OVER $200 MILLION (EST.)

- **INTEGRATED DESIGN-MANUFACTURING-SUPPORT SYSTEM WITH DATABASES FOR A MAJOR AIRCRAFT SYSTEM**

  OVER $750 MILLION (EST.)

- **TOTAL COMPANY-WIDE CALS SYSTEM FOR A MULTI-PRODUCT MAJOR AEROSPACE COMPANY**

  $6 BILLION TO $10 BILLION (EST.)

SOURCE: REFERENCE [18]

Slide 35

From our briefing notes [18], we found three order-of-magnitude cost estimates that bear a reasonable relationship to each other and are presented here to indicate the probable costs of implementing IDMS systems.

The first is for the development and installation of an integrated information system for a military aircraft that has completed the production phase. The goal is to provide a database containing the design and technical information to support the ongoing logistics and operations of the aircraft. The estimate of approximately a quarter of a billion dollars includes the development, procurement, installation and testing of the IDMS system at the depot level. It does not include any additional government investment that may be needed to access the data at remote sites or bases.

The second estimate is for a fully integrated IDMS system for one major aircraft system covering the design, development, production, and logistics support planning efforts. Although this estimate is three times larger than that for a logistics support system only, would include the automation and information integration of the design and production departments. Another source noted that each automated workstation cost $55,000 (excluding centralized data storage, local area networks, and software) when an IDMS system was installed in a publishing department. In the light of that information, a cost of over $750 million for an integrated information system for a total aircraft system is reasonable.

That estimate is further bolstered by an estimate provided by a major producer of a number of aircraft systems. This company has prepared an estimate for implementing a company-wide IDMS with separate but interactive databases for each of its systems. At this early stage of planning, they estimate a total investment of $6 billion to $10 billion over a twelve-year period.

The first estimate is based on budget planning estimates, the third is based on estimates developed for internal management review. Although the second estimate was developed on a less-rigorous basis than the others, the order-of-magnitude is in line with the others.

SELECTED IDMSS SAVINGS

DESIGN		PRODUCTION		OTHER	
DESIGN TIME AND COSTS	15-66%	PRODUCTION ENGR.	33%	LOG. SPT. PLNG.	30-60%
PROCESS PLANNING	58%	MATERIAL COSTS	4-46%	LEAD TIME	30-88%
		MFG. LABOR COSTS	5-40%	SPACE	69%
		TOOLING	12%	WIP INVENTORY	6-67%
		SCRAP	10-60%	MACHINE PROD.	200-300%
		QC COSTS	60%	ENGR. PROD	300-3500%
		OVERALL PROD. COSTS	42%		

SOURCE: REFERENCES [12], [16], [17], [18]

Slide 36

This vugraph shows a summary of reported savings and benefits experienced by companies implementing various parts of IDMS systems. The data speak for themselves and show the potential value to industry of <u>properly</u> implementing advanced technology in design and production.

In our review of the costs and benefits of IDMS (CALS)-type applications, much emphasis was placed by all contacts on the need for cultural change by all concerned if the results shown here were to be realized. One author [19] noted the following tactics that would help in the application of computer-aided activity:

- Generate a sense of purpose.
- Provide sufficient education.
- Work together and surrender turf if necessary.
- Resolve issues.
- Overcome organizational inertia.
- Rework the informal system.
- Address job security.
- Encourage participation in the planning.

TASK 4: RECOMMENDATIONS

1. CONTINUE MEETINGS, WORKSHOPS, AND SYMPOSIA FOR ALL MANAGEMENT LEVELS
   - CALS EXPO
     - -- REGIONAL
     - -- SMALL BUSINESS
     - -- CIVIL SECTOR
   - MANAGEMENT SEMINARS
     - -- NEED TOP MANAGEMENT AGREEMENT
     - -- NEED TO BOLSTER INTENT

2. DEVELOP A COST/BENEFIT METHODOLOGY THAT CAN BE APPLIED BY DoD PROGRAM MANAGERS IN EVALUATING PROPOSALS CONTAINING IDMS SYSTEMS

3. CONTINUE RESEARCH INTO MODIFIED COST STRUCTURES/ACCOUNTING SYSTEMS FOR VARIOUS TYPES OF WEAPON SYSTEMS

4. RESEARCH/DEVELOP COST/BENEFIT STRUCTURES FOR IDMS INFORMATION SYSTEMS

TASK 4: RECOMMENDATIONS

Slide 37

Our recommendations fall into three categories: motivation/incentive; application methodology; structures development.

All industries, including the defense industry, try to be responsive to their customers' needs and wants. To prove to the private sector that CALS (IDMS) is not a temporary fad, a regular and continuing contribution is needed from the DoD in the form of goals and plans. This activity should also be aimed at all levels of the corporation for it is top management that ultimately makes the investment decisions and middle and lower management that implement the decisions.

Therefore, we recommend that DoD continue and expand its ongoing program of participation in meetings, seminars, and workshops. This participation can provide information and examples of successful IDMS implementations as well as indicate the government's information needs.

As government program managers attempt to apply IDMS to their programs in accordance with the Deputy Secretary of Defense memorandum [7], some consistent guidance will be needed to ensure that industry does not work to conflicting standards. We therefore recommend that DoD quickly start to develop guidelines for program managers and acquisition executives in evaluating contractor proposals and evaluating contractor performance in providing integrated information systems.

As we have seen in the structures developed to date, it would be inappropriate to require contractors to evaluate and report all costs and benefits in accordance with a rigid, all-inclusive structure. However, there is a need to provide consistency among the various programs to permit appropriate evaluation. Therefore, we recommend that the DoD work with corporations, industry associations, professional associations, and major accounting firms to better understand the differing methods for accounting for advanced technology implementation and to participate in developmental studies.

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